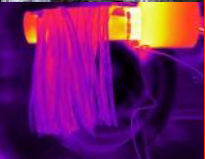
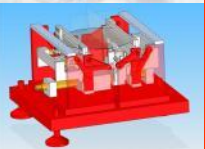


# MSFC Technology Portfolio and Space Technology Program Overview

Andrew S. Keys, Center Chief Technologist  
28 November 2012



# NASA Around the Country





# MSFC - From Exploration to Opportunity



**\$2.88 billion (FY2009)  
impact to  
Alabama economy**



**5,500 employees  
(civil service and contractor,  
approximate number)**



**3rd largest employer  
in the Huntsville – Madison  
County area**



**4.5 million square feet  
of space occupied  
in Huntsville**



**2.2 million square feet  
of manufacturing space at  
Michoud Assembly Facility**



# Marshall's Role in Agency Missions



## ***Four Core Technology Themes***

Space Transportation/Launch Vehicle  
Technology and Development



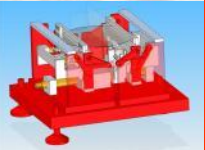
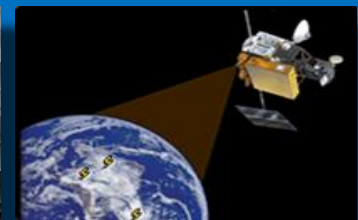
Propulsion Systems  
Technology and Development



Space Systems  
Technology, Development,  
and Integration



Scientific Research





# Space Transportation/Launch Vehicle Technology and Development



## Space Transportation/Launch Vehicle Technology and Development

HEOMD

STMD

Cross-cutting

- **Space Launch System Program**
  - SLS Program Management
  - Boosters
  - Engines
  - Stages
  - Avionics
  - Spacecraft & Payload Integration
  - Advanced Development
- **Commercial Orbital Transportation System (COTS) Program**
- **Commercial Crew Development (CCDev) Program**
- **Advanced Exploration Systems Program**
  - Manufacturing Innovation
  - Soldier Warfighter Operationally Responsive Deployer System (SWORDS)
- **Game-Changing & Cross-Cutting Space Technology Development**
  - Small Payloads Launch Architecture





# Propulsion Systems Technology and Development



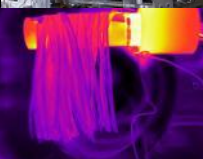
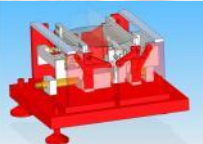
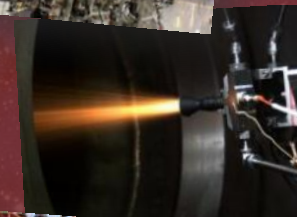
## Propulsion Systems Technology and Development

HEOMD

STMD

Cross-cutting

- MPCV Launch Abort System (LAS)
- Shuttle Transition & Retirement
- Rocket Propulsion Test (RPT)
- Nuclear Cryogenic Propellant Stage
  - Liquid Propulsion Systems
- **Game-Changing & Cross-Cutting Space Technology Development**
  - Advanced In-Space Propulsion
  - Composite Cryogenic Propellant Tank
  - Nanoenergetics Propulsion Technology
  - Cryogenic Propellant Transfer and Storage
- **National Institute for Research of Propulsion Systems (NIRPS)**





# Space Systems Technology, Development, and Integration



## Space Systems Technology, Development, and Integration

**HEOMD**

**STMD**

**Cross-cutting**

### **International Space Station (ISS) Program**

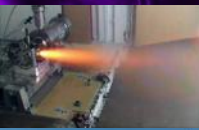
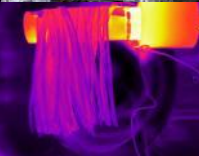
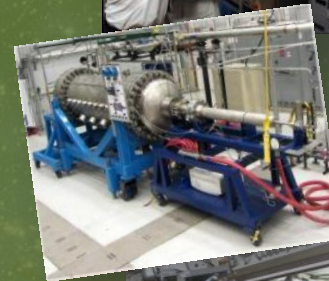
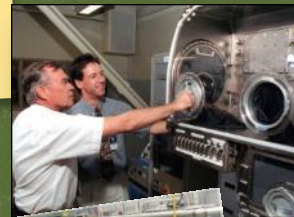
- Payload Ops Integration Center (POIC)
- Payload Ops Integration Function (POIF)
- Multi-Use Payloads
- Materials Science Research Rack (MSRR)
- Microgravity Science Glovebox (MSG)
- ECLSS Sustaining
- ECLSS Spares

### **Advanced Exploration Systems (AES) Program**

- Atmosphere Resource Recovery
- Lunar Mapping & Modeling

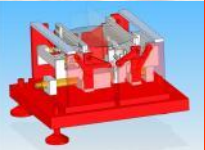
### **Game-Changing & Cross-Cutting Space Technology Development**

- Nuclear Systems
- Autonomous Systems
- Next Generation Life Support





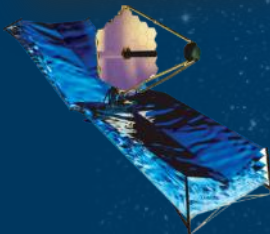
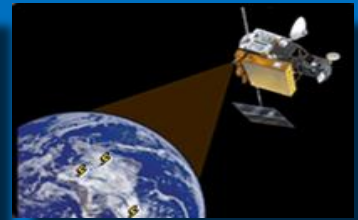
# Scientific Research



## Scientific Research

SMD

Cross-cutting



### • Planetary Science

- Discovery/New Frontiers (DNF) Program
- Lunar Quest Program (LQP)

### • Earth Science

- Robotic Lunar Lander Development (RLLD) Project
- SERVIR
- Hurricane Imaging Radiometer (HIRAD)
- Short-term Prediction Research & Transition (SPoRT) Center
- Partnering Earth Observations for People Living Environmentally Arctic Collaboration Environment (PEOPLE-ACE)

### • Astrophysics

- Chandra X-ray Observatory
- Fermi Gamma-ray Burst Monitor (GBM)
- Advanced Mirror Technology Development (AMTD)

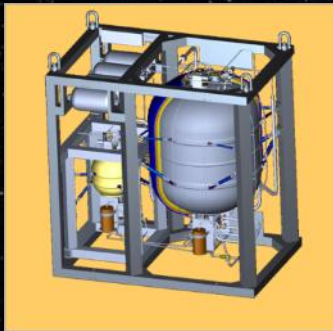
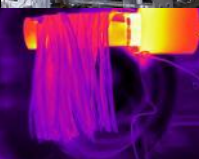
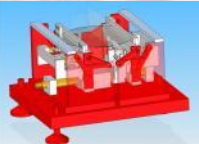
### • James Webb Space Telescope (JWST) Program

### • Heliophysics

- Hinode
- Solar Ultraviolet Magnetograph Instrument (SUMI)
- Solar Wind, Electrons, Alphas, and Protons (SWEAP)



# MSFC Technology Emphasis Areas



**Advanced In-Space Propulsion and Cryogenic Technologies**



**Affordable, Innovative Technologies for Landers and Sample Return**



**In-Space Habitation Technologies with emphasis on Nodes and Life Support Systems**



**X-ray Astrophysics and Telescope Systems**



**Rapid, innovative, affordable manufacturing of propulsion components**



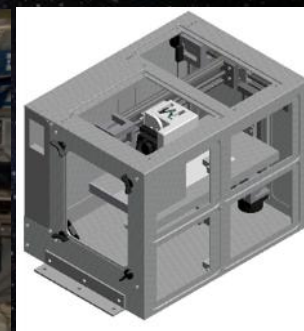
**In-Space Propulsion (Pulse Power, Electric)**



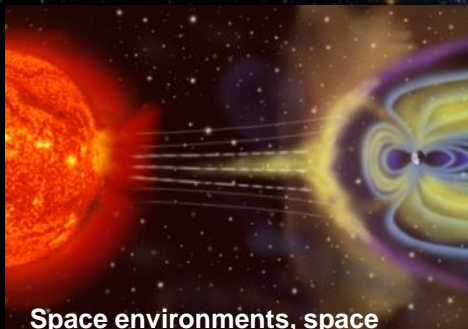
**Low Cost/Responsive Launch for Small Payloads**



**Innovations and technologies supporting small, affordable ISS payloads**



**Advanced manufacturing with emphasis on in-situ fabrication and repair**



**Space environments, space weather prediction and assessment**



**In-Space Propulsion (Nuclear)**



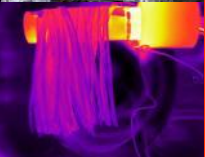
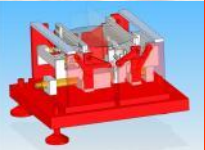
**In-Space Propulsion (Solar Sail, Tethers)**



**Small Satellite and Small Spacecraft Technologies**



# NASA's Mission Directorates



**Aeronautics  
Research Mission  
Directorate (ARMD)**



**Human Exploration and  
Operations Mission  
Directorate  
(HEOMD)**



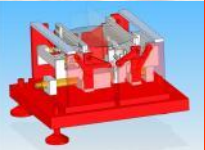
**Science Mission  
Directorate (SMD)**



**Space  
Technology  
Program (STP)**



# NASA's Mission Directorates



**Aeronautics  
Research Mission  
Directorate (ARMD)**



**Human Exploration and  
Operations Mission  
Directorate  
(HEOMD)**



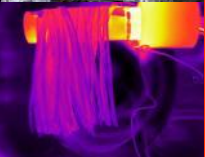
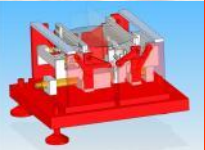
**Science Mission  
Directorate (SMD)**



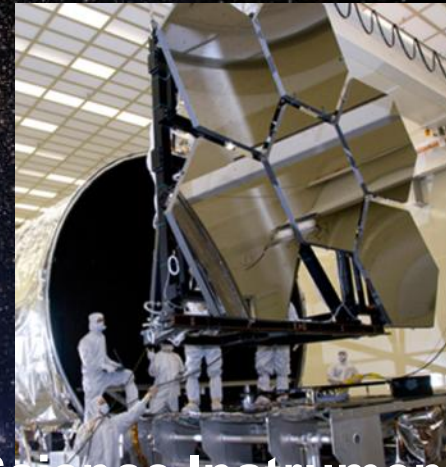
**Space  
Technology  
Program (STP)**



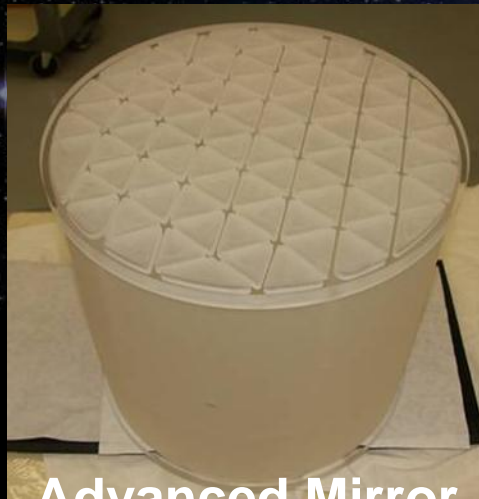
# MSFC SMD Technology Projects



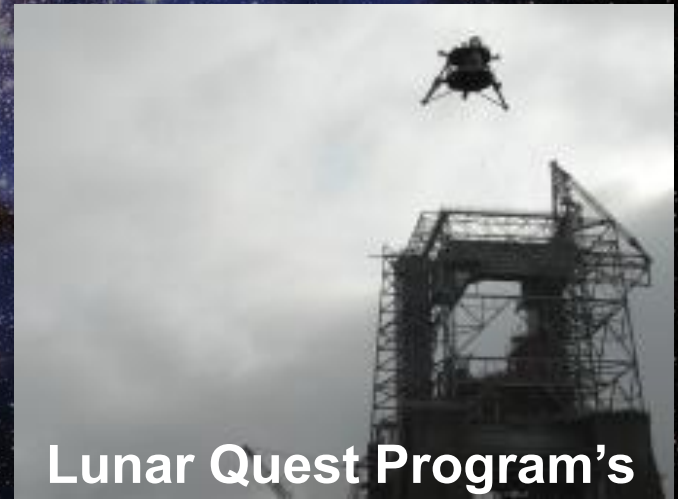
**X-Ray Optics**



**Science Instruments**



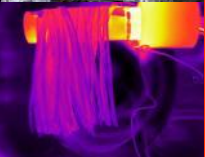
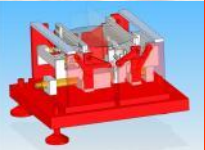
**Advanced Mirror  
Technology Development**



**Lunar Quest Program's  
Mighty Eagle Lander**



# NASA's Mission Directorates



**Aeronautics  
Research Mission  
Directorate (ARMD)**



**Human Exploration and  
Operations Mission  
Directorate  
(HEOMD)**



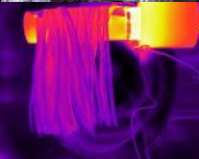
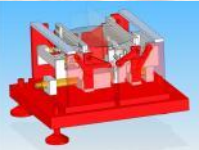
**Science Mission  
Directorate (SMD)**



**Space  
Technology  
Program (STP)**



# MSFC Involvement in HEOMD AES Program



**Nuclear Cryogenic Propulsion Stage:**  
Nuclear Thermal Rocket Element  
Environmental Simulator



**Habitation Systems:**  
Advanced Deep  
Space Habitat



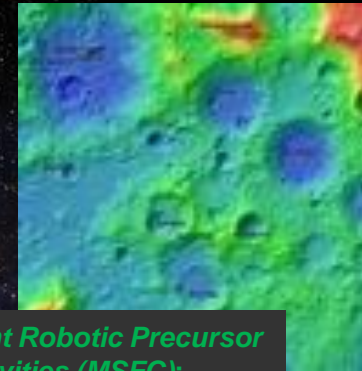
**Radiation Protection:**  
Advanced Neutron  
Spectrometer



**Morpheus Vertical  
Test Bed (JSC)**



**Life Support Systems:**  
Atmosphere Resource Recovery  
and Environmental Monitoring



**Joint Robotic Precursor  
Activities (MSFC):**  
Lunar Mapping and  
Modeling Portal



**Autonomous Mission  
Operations (ARC):**  
Timeliner Software  
(Draper Labs) and  
Integration

**MSFC Leads  
MSFC Participates**



# SLS – America's Heavy Lift Rocket



- Safe, affordable and sustainable
- Carries the Orion Multi-Purpose Crew Vehicle (MPCV)
- Supports national missions beyond Earth orbit
- Does not preclude back-up for ISS transportation
- Initial lift capacity of 70 metric tons (mt) evolving to 130 mt
- Builds on Saturn, Shuttle and Ares



Solid Rocket  
Motor Test



Friction Stir  
Welding



Shell Buckling  
Test



Upper Stage  
J-2X Engine



J-2X Engine  
Tests



Core Stage  
RS-25  
Engines

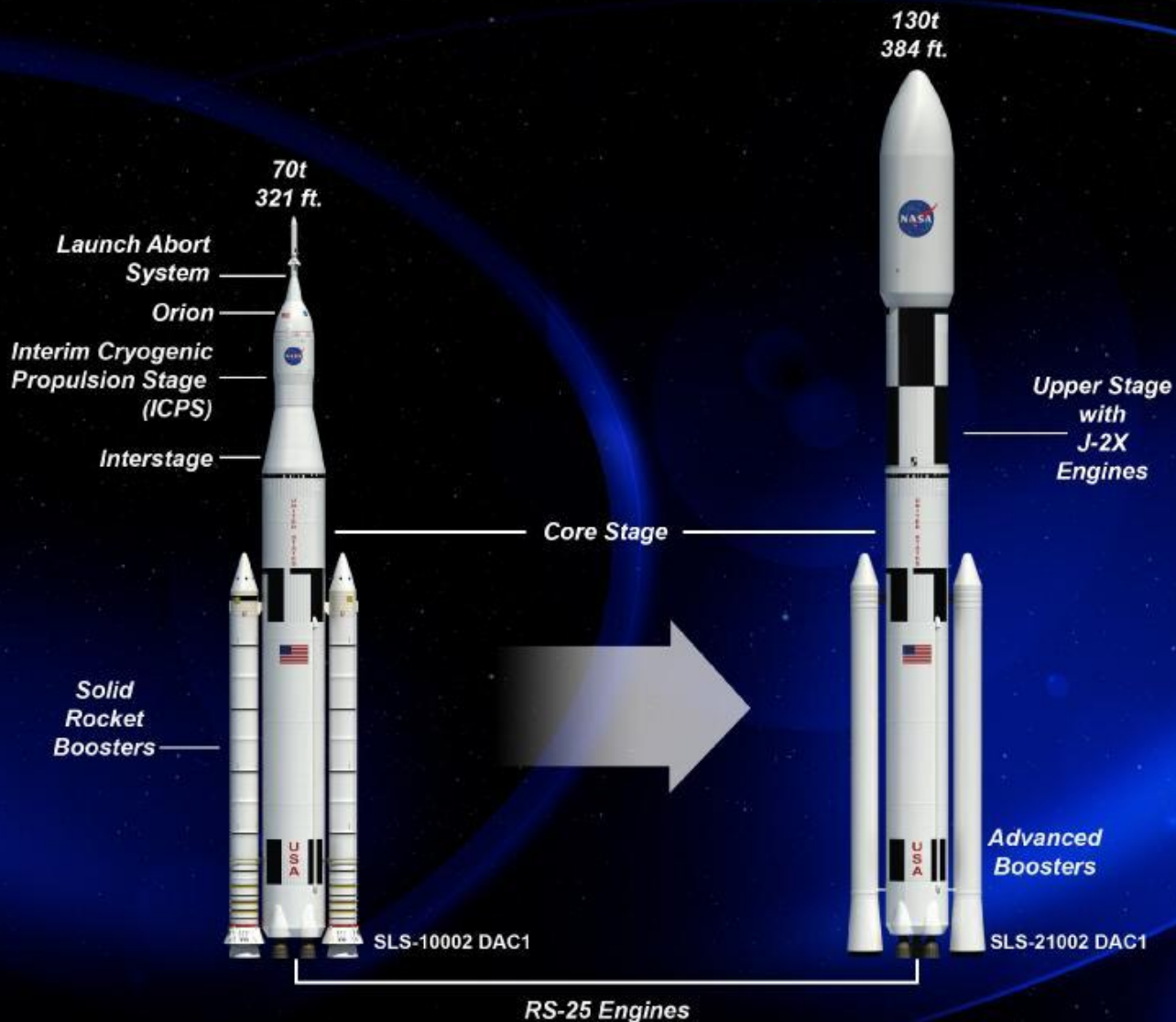
*Marshall's capabilities and facilities are  
launching the future of space vehicle development.*



# HEOMD Space Launch System

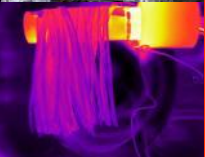
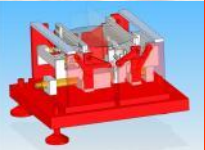


## SLS Architecture Reference Configuration

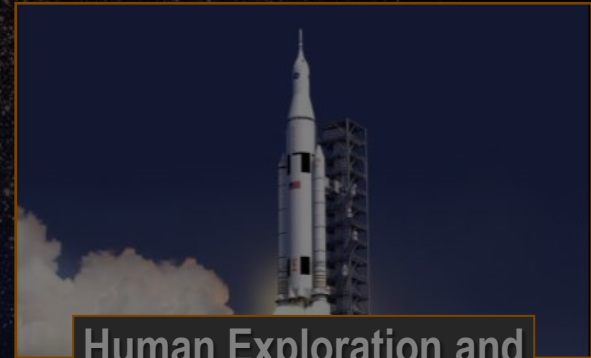




# NASA's Mission Directorates



Aeronautics  
Research Mission  
Directorate (ARMD)



Human Exploration and  
Operations Mission  
Directorate  
(HEOMD)



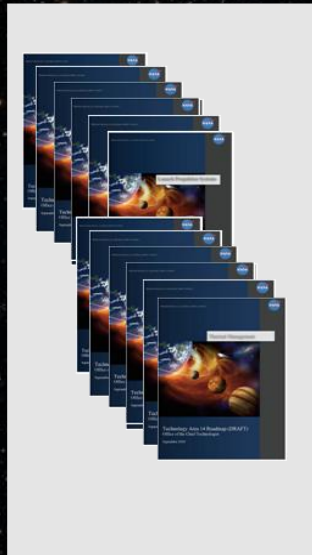
Science Mission  
Directorate (SMD)



Space  
Technology  
Program (STP)



# NASA's Space Technology Portfolio Perspectives and Process



## Space Technology Roadmaps

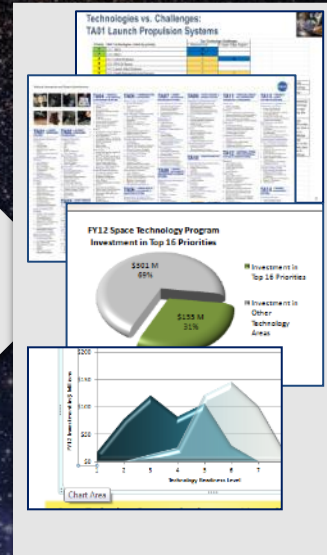
140 challenges (10 per roadmap)  
320 technologies  
20 year horizon

Gives priority to:

- 100 top technical challenges
- 83 high priority technologies (roadmap-specific)
- 16 highest of high technologies (looking across all roadmaps)
- Immediate 5 year horizon



## NRC Study



## Space Technology Investment Plan

### Updated ST Roadmaps:

- Incorporate NRC Study Results

### Developing a Strategic Space Technology Investment Plan:

- Identify current investments
- Identify current MD/Office priorities
- Identify opportunities for partnership
- Analyze gaps against current budget and capabilities
- Develop immediate 4-year horizon



## Execution

### Technology Portfolio Investments

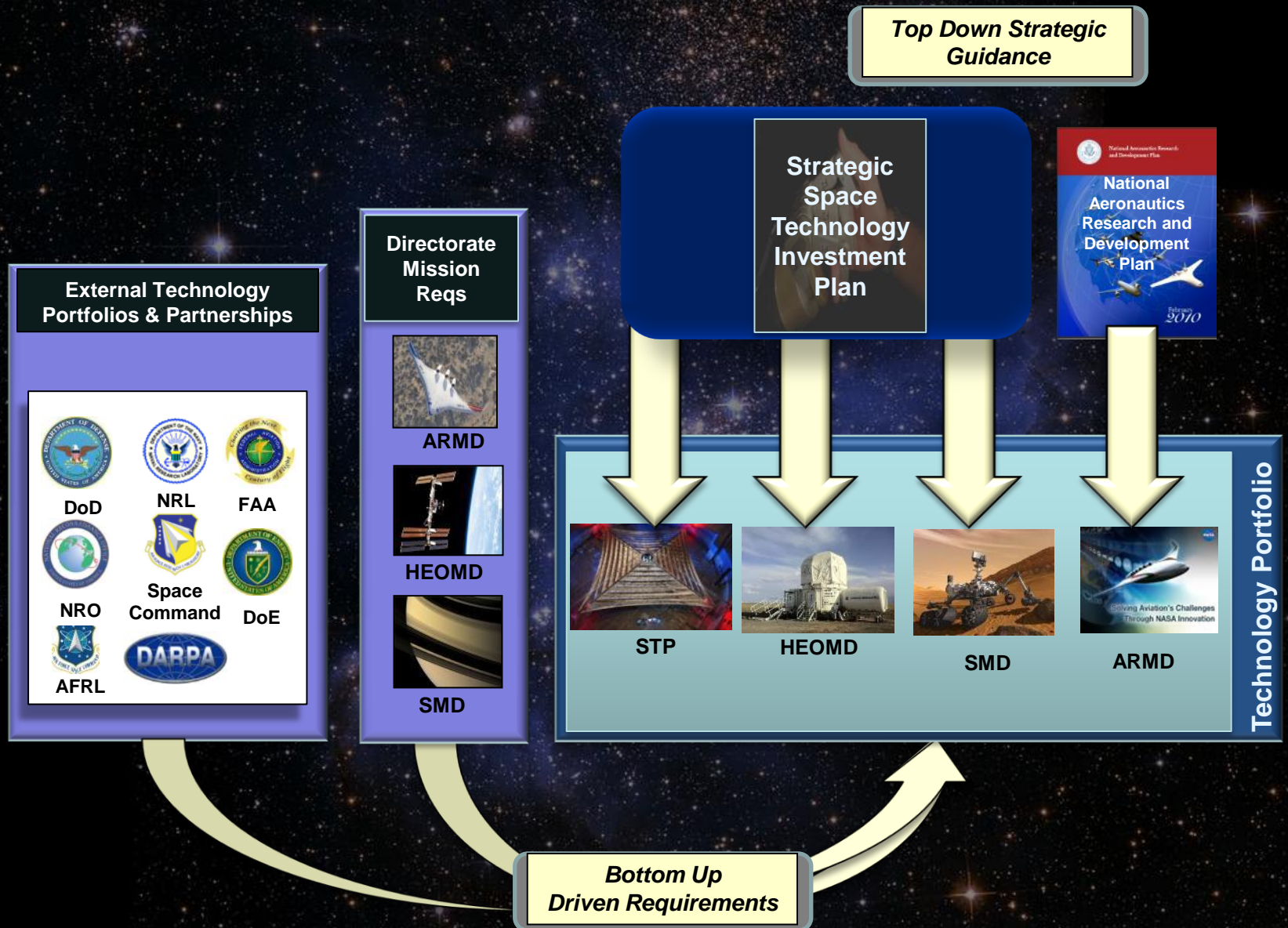
- Technology Developments (across full TRL spectrum)
- Flight Demonstrations

Must reflect:

- Affordability
- Technical Progress and Performance
- Mission Needs and Commitments
- Stakeholder Guidance



# NASA's Space Technology Portfolio





# OCT Organizational Chart



## Office of the Chief Technologist, NASA Headquarters

### Front Office

Admin Support Joyce Rhym

Mason Peck, Chief Technologist	9081	x1180
Jim Adams, Deputy Chief Technologist	9083	x1180
Michael Gazarik, Director of Space Technology Programs	6M80	x1180
Kim Butler, Administrative Specialist	6M77	x2341
Evelyn Vidal-Roles, Office Manager	6K86	x0728
Marcia Joseph, Admin Assistant (Offices)	6M71	x4717
Joyce Rhym, Executive Assistant	9N79	x1180

### Communications and Outreach

Admin Support Marcia Joseph

Mike Green, Director/Executive Officer	9P83	x4710
Diane Powell, Non-Traditional Outreach	9079	x1904
Trish Talbert, Web Design	6P71	x4422
Janelle Turner, Outreach	6H72	x0704
Derek Wang, Outreach	6H70	x5185
Stacey Brooks, Outreach	6H82	x1890
Anyah Dembling	6N71	x5195
Hena Kazmi	6O84	x0863

### Innovative Partnerships Office

Admin Support Marcia Joseph

Jason Derleth, Partnership Development	6G80	x0987
Diana P. Hoyt, Innovation/Partnership Development	9P69	x1893
Daniel Lockney, Program Specialist	9N70	x2037
Jennifer Gustetic	9P67	x5693
LaNetra Tate	6F72	x1071

### Cross Agency Support

Sonja Alexander, Communications	9R20	x1761
Jeffrey Heninger, OGC	9S13	x0482
Richard Fullerton, OSMA	5Z45	x1453
Kent Bress, OIIR	2Z45	x0269
Courtney Graham, OGC	9T13	x3648
Gene Johnson, Procurement	5L 86	x4703
David Steitz, Communications (Embedded)	9O74	x1730
Liz Williams, OIIR	2Z82	x0849

### Space Technology Program

Mike Gazarik, Director	6P84	x0411
James Reuther, Deputy Director	6N80	x5212
Doreen Abdul-Malik, Support	6P75	x0547

### Program Execution

Admin Support Doreen Abdul-Malik

James Reuther, Acting Director	6N80	x5212
Harry Partridge, SE	6P82	x4431
<b>Game Changing Development Program</b>		
Tibor Balint - Program Executive	6Z41	x2368
<b>Franklin Small Satellite Subsystem Technologies</b>		
Mike Skidmore, L2 PM (ARC)	(650) 604-6069	
<b>Technology Demonstration Missions</b>		
Bonnie James, PE	6R28	x0370
John McDougal, L2 PM (MSFC)	(256) 961-7481	
<b>Edison Small Satellite Demonstration Missions</b>		
Andrew Petro, SE	6G84	x0310
Bruce Yost, L2 PM (ARC)	(650) 604-0681	
<b>Flight Opportunities</b>		
LK Kabendran, PE	6Z51	x2528
John Kelly, L2 PM (DFRC)	(661) 276-2308	
Patrick Connell, Early Stage Program Support	6L71	x2224
<b>Space Tech Research Grants</b>		
Claudia Meyer, PE	(216) 509-5606	
Andy Eckel, L2 PM (GRC)	(216) 433-8185	
<b>NIAC</b>		
Jay Falzer, PE	6F82	x4545
Ron Turner, Sr. Science Adviser	(571) 239-5628	
Kathy Reilly, Outreach Coordinator	(847) 890-1873	
<b>SBIR/STTR</b>		
Rich Leshner	6R11	x4920
Gary Johns, L2 PM (ARC)	(650) 604-6595	
<b>Centennial Challenges</b>		
Sam Ortega, L2 PM (MSFC)	(256) 684-9350	
Larry Cooper, Program Executive	6Q15	x1531
<b>Center Innovation Fund</b>		
Mimoo Dastoor, PE	6Q33	x4518

### Center Chief Technologists

John Hines, ARC	(650) 604-5538
David Voracek, DFRC	(661) 810-3552
Howard Ross, GRC	(216) 433-2562
Peter Hughes, GSFC	(301) 286-2342
Jonas Zmuidzinas, JPL	(818) 393-7600
John Saiz, JSC	(281) 483-8864
Karen Thompson, KSC	(321) 867-7555
Keith Belvin, LaRC	(757) 864-4319
Andrew Keys, MSFC	(256) 544-8038
Ramona Travis, SSC	(228) 688-3832

### Program Management & Integration

Admin Support Kelly Johnson

Faith Chandler, Acting Director	6P84	x0411
Carl Ray, Portfolio Systems	6Q86	x4652
Denise Podolski, Director Other Gov't Agency	9M81	x1504
Mark Redlinger, Other Gov' Agency Staff	9N72	x4591
Howard Ross - Roadmap	6O77	x5703
Damian Taylor - Prog Mgmt Exec Staff	6N73	x1432
Prasun Desai, SE	6O73	x3755
Randy Lillard, SE	6P86	x0231
Mike Battaglia	6Q88	x4658
Joseph Grant	6R34	x0070
Wade May	6Q81	x4764
Jan Rogers	6O82	x1068

### Resources Management

Admin Support Marcia Joseph

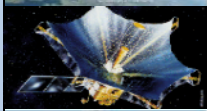
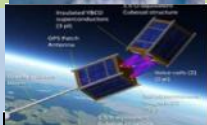
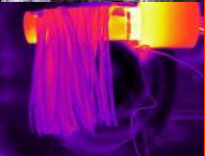
Robert Carver, Director	6E80	x1782
Patrick Murphy - Deputy Director	6E70	x1114
Sharon Alexander- Prog Analyst	6F72	x1522
Anita Babb-Bascomb - Early Stage/IPO & SI	6G82	x3604
Peter Tischen- Crosscutting Capability Demonstration	6G72	x1139
Sharmaine Carter - Budget Support/Programs	6G75	x4486
Kina Ratanjee- Strategic Scheduler	6E73	x1001
Ruth Krat - Prog Analyst	6G70	x1706
Kathryn Suatt, Prog Analyst	6G73	x1084

Solicitations Chief - Vacant

Senior Technical Officer- Harry Partridge



# NASA's Space Technology Program (STP)



**Space Technology Research Grants:** Provides researchers within academia, Government, nonprofit organizations and industry with the opportunity to engage in groundbreaking research in advanced space technology.

**NASA Innovative Advanced Concepts (NIAC):** Engages innovators within and external to the Agency on aerospace system concept studies.

**Center Innovation Fund:** Stimulates aerospace creativity and innovation at the NASA Centers.

**Small Business Innovative Research (SBIR)/Small Business Technology Transfer (STTR):** Provides an opportunity for small businesses and research institutions to participate in NASA sponsored research and development efforts in key technology areas.

**Centennial Challenges:** Addresses key technology needs through prize competitions that facilitate new sources of innovation outside the traditional aerospace community.

**Game Changing Development:** Seeks disruptive technologies for future science and exploration missions.

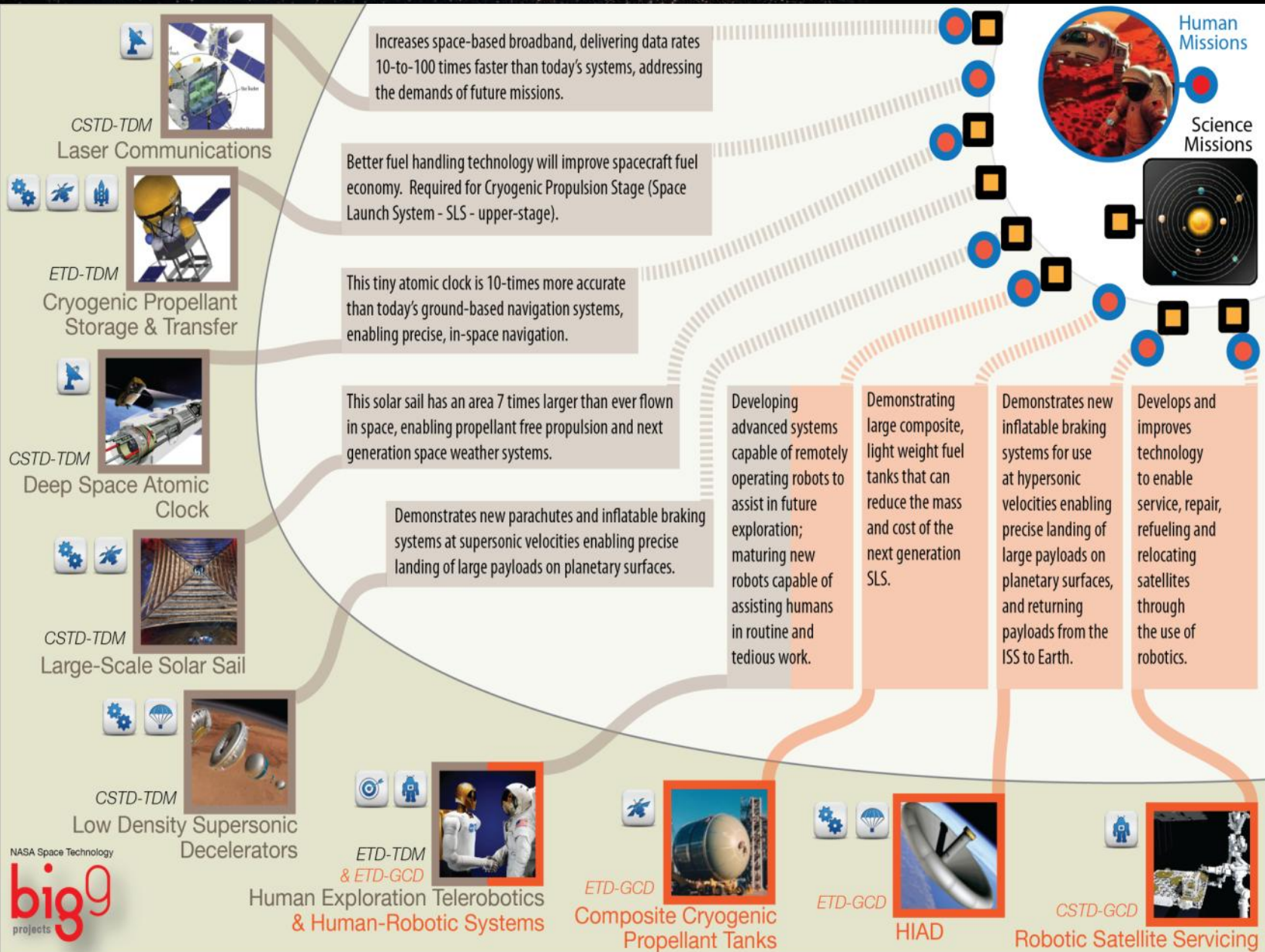
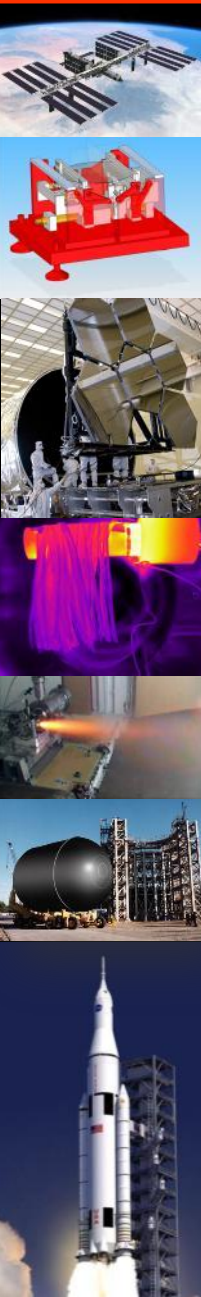
**Small Spacecraft Technology:** Develops and operates a series of small satellite technology (Merged previous Franklin and Edison programs).

**Technology Demonstration Missions:** Demonstrates crosscutting technologies in the space or relevant operational environment.

**Flight Opportunities:** Matures technologies by providing access to the relevant environment while also facilitating the development of the commercial reusable suborbital transportation industry.



# STP's "Big 9"





# Space Technology Research Grants Program Overview

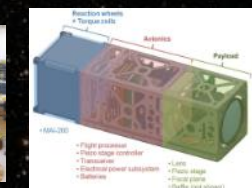
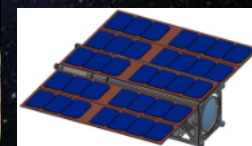
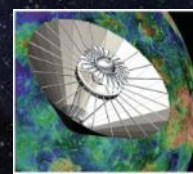
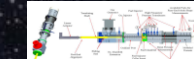
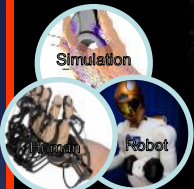
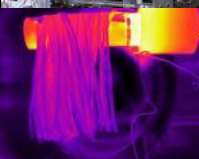
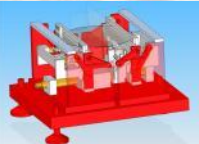


**PROGRAM:** To accelerate the development of push technologies through innovative efforts with high risk/high payoff and develop the next generation of innovators through:

- **Space Technology Research Opportunities – Early Stage Innovation (STRO-ESI):** technology portfolio of groundbreaking research in advanced space technology
- **NASA Space Technology Research Fellowships (NSTRF):** Competitive selection of U.S Citizen / permanent resident graduate students developing promising technologies in support of future NASA missions and strategic goals

## ACCOMPLISHMENTS/MILESTONES (FY 2012/2013):

- **STRO-ESI:** One year awards with possible renewals; ~\$200K/year
- **NSTRF:** 80 Fellows in inaugural class; NSTRF12 class will be announced ~ August 2012

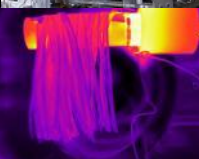
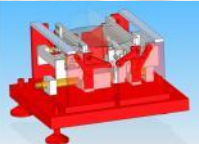




# Center Innovation Fund and NASA Innovative Advanced Concepts (NIAC)



- **PROGRAM:** The objective of the Center Innovations Fund (CIF) is to stimulate and encourage creativity and innovation from within the NASA Centers. Distributed among the NASA Centers, this program will provide seed funding for new technologies, innovations and creative ideas. These funds will allow Centers to support low TRL innovative technology initiatives that leverage Center talent and capability.
- **ACCOMPLISHMENTS/MILESTONES (FY 2012/2013):**
  - In FY 2011 150 Projects and studies were selected and implemented.
  - In FY 2012 CIF Selections of projects will be completed by March 1.
- **PROGRAM:** NASA Innovative Advanced Concepts (NIAC) funds early studies of visionary, long term concepts - aerospace architectures, systems, or missions (not focused technologies). The intended scope is very early concepts: Technology Readiness Level 1-2 or early 3; 10+ years focus
- **ACCOMPLISHMENTS/ MILESTONES (2012-2013):**
  - Jan 9 -- NIAC Phase I NRA released
  - March 27-29 -- NIAC Spring Symposium in Pasadena, CA
  - April 3 -- NIAC Phase II NRA released
  - July -- announce Phase I and II selections
  - Sept 1 -- FY12 studies (Phase I and II) commence
  - Sept 30 -- FY11 final reports due





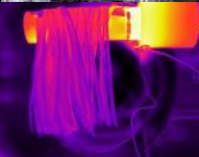
# Small Business Innovation Research and Small Business Technology Transfer (SBIR/STTR)



**PROGRAM:** Stimulate technological innovation and support NASA's innovative research to develop technologies for NASA projects while spurring economic growth through commercialization.

## **ACCOMPLISHMENTS/MILESTONES (FY 2012/2013):**

- Selected 260 SBIR Phase 1 proposals selected across 37 states and 85 SBIR Phase 2 proposals selected across 26 states\*
- Selected 40 STTR Phase I proposals selected across 18 states\*
- STTR Phase 2 selections expected in April 2012
- Expect to award Phase 2E awards in FY 2012
- Working with Small Business Administration (SBA) to assess implementation of new requirements in recent SBIR/STTR Reauthorization. Expecting Policy Guidelines from SBA in accordance with schedule from reauthorization.





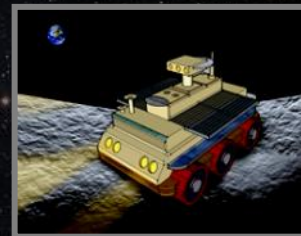
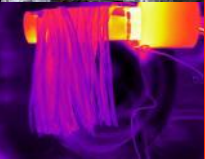
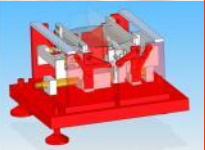
# Centennial Challenges



**PROGRAM:** The Centennial Challenge Program (CCP) directly engages non traditional sources advancing technologies of value to NASA's missions and to the aerospace community. CCP offers challenges set up as competitions that award prize money to the individuals or teams to achieve the specified technology challenge.

## ACCOMPLISHMENTS/MILESTONES (FY 2012/2013):

- Green Flight Challenge awarded the largest ever aviation prize for demonstration of over 400 mpg energy efficiency in a full scale, piloted, electric powered aircraft.
- Sample Return Robot Challenge will host a competition in June 2012 to demonstrate a that a robot that can locate and retrieve geologic samples from a wide and varied terrain without human control.
- In FY 2013 the Night Rover Challenge will have a competition to demonstrate a high energy density storage systems that will enable a rover to operate throughout lunar darkness cycle. The Sample Return Robot Challenge will hold a second round of competition in Summer 2013.





# Game Changing Development (GCD) Program Overview



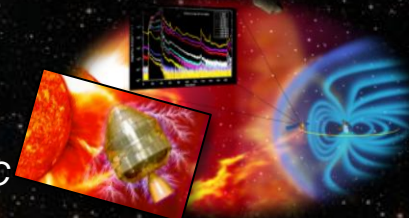
## PROGRAM

- To identify and rapidly mature innovative/high impact capabilities and technologies that may lead to entirely new approaches for the Agency's future space missions.
- The program will investigate novel ideas and approaches that have the potential to revolutionize future space missions.



## MILESTONES/ACCOMPLISHMENTS FY2012-2013

- **Composite Cryotank Technologies and Demonstration (CCTD):**
  - Develop 2m-diameter Composite Cryotank Fabrication
  - Conduct 2m-diameter Composite Cryotank Pressure Testing at NASA MSFC
  - Test 5m-diameter Composite Cryotank at liquid hydrogen temperatures, under load at NASA MSFC
- **Hypersonic Inflatable Aerodynamic Decelerators (HIAD):**
  - Suborbital flight demonstration test of IRVE-3 at Wallops Flight Facility – May 2012
  - Conduct Next Generation Wind Tunnel Tests & 8ft. Wind Tunnel Tests at NASA LaRC
  - Conduct National Full-Scale Aerodynamics Complex, NFAC-2 testing at NASA ARC
  - Conduct 6 meter Large Core Arc Tunnel (LCAT) testing with packed coupons at Boeing
- **Human Robotic Systems (HRS):**
  - Integrate NASA-ARC developed navigation software on NASA-JSC-based Centaur Rover
  - Complete Rover Ballistic Cannon assembly at NASA JSC
  - Ready for testing of the Next Generation Jet Pack Prototype at NASA JSC
  - Ready for testing of the Rover Ballistic Cannon and Free Flyer at NASA JSC





# Edison Small Satellite Demonstration Missions and Flight Opportunities Program Overview

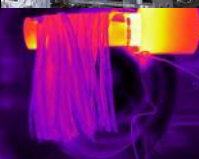
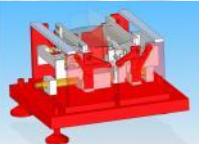
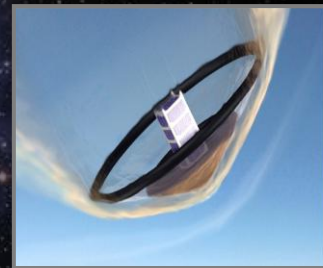


**EDISON SMALL SATELLITE DEMONSTRATION MISSIONS PROGRAM:** Low-cost flight demonstrations of new capabilities and technologies for small spacecraft.

- **ACCOMPLISHMENTS/MILESTONES (FY 2012/2013):**
  - Preparing PhoneSat 1.0 for launch in Summer 2012 demonstrating use of commercial smart phones for onboard satellite navigation, control and communications
  - Began development of EtherSat mission to demonstrate capabilities of satellite swarms for a range of missions projected launch in 2013
  - Released open solicitation for proposed small spacecraft demonstration missions for communications, propulsion and proximity operations
    - Selecting projects for award in August 2012
    - 2 to 3 year projects, less than \$10 to \$15 million per project

**FLIGHT OPPORTUNITIES PROGRAM:** Develops and provides opportunities for space technologies to be demonstrated and validated in relevant environments. Fosters the development of the commercial reusable suborbital transportation industry.

- **ACCOMPLISHMENTS/MILESTONES (FY 2012/2013):**
  - Establishing a pipeline of technology payloads to utilize the anticipated commercial suborbital flight opportunities
    - Received 35 proposals for payloads in response to payload solicitation
    - Collaborating with Game-Changing Development Program to release NASA Research Announcement for payload development
  - **Planned commercial flight opportunities**
    - Three Parabolic Flight Campaigns
    - Flights on Masten Space Systems, Near Space Corp, UP Aerospace, and Virgin Galactic
    - Qualification flights of Armadillo Aerospace, Whittinghill Aerospace, and XCOR Aerospace
  - **Formed Partnership with New Mexico Space Grants for flying Student Payloads**
  - **Development of Commercial Vertical Testbed**
    - Integration of Draper Labs Technology on Masten Space Systems' Vehicle

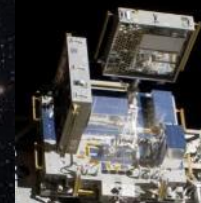
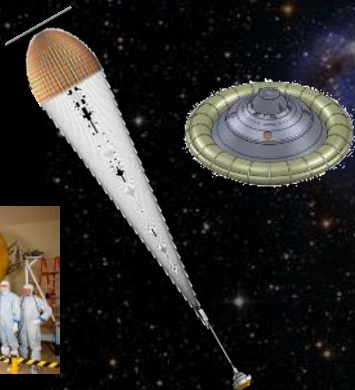
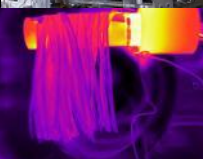
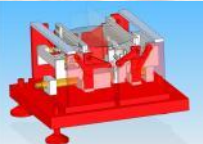




# Technology Demonstration Missions

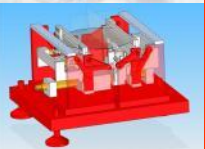


- **PROGRAM:** The Technology Demonstration Missions (TDM) program provides demonstration opportunities, bridging the gap between early developments and mission infusion by maturing crosscutting, system-level, technologies through demonstration in a relevant operational environment.
- **ACCOMPLISHMENTS/MILESTONES (FY 2012/2013):**
  - Supersonic sled testing and parachute testing in the Low Density Supersonic Decelerator (LDSD) Project at China Lake
  - Multiple SPHERES and Robonaut demonstrations on ISS under the Human Exploration Telerobotics (HET) Project
  - Multiple Precision Landing/Hazard Avoidance flight tests on the Vertical Test Bed under Autonomous Landing Hazard Avoidance Technology (ALHAT) Project
  - Aerothermal data collection during Mars Science Lab Entry and Descent under the MSL Entry Descent and Landing Instrumentation (MEDLI) Project
  - Qualification testing of Solar Sail components and subsystems under the Solar Sail Demonstration (SSD) Project





# Technology Transfer



Quantum Devices HEALS Technology



High-Strength, High-Temp Aluminum Alloys in Johnson and Evinrude Pistons



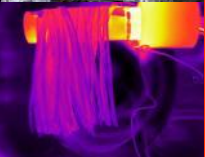
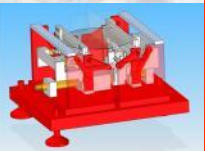
Vortex Combustion Technology Aiding Fire Suppression



Multi-function Agile Remote Control Robot (MARCbot)



# Let's Go!



Pitt Rawlings 2009